

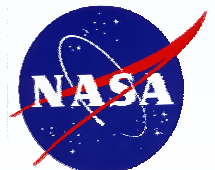
Conceptual Design of a Satellite Bus Using Internet Technologies

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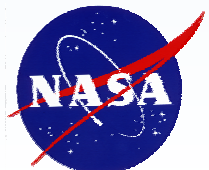
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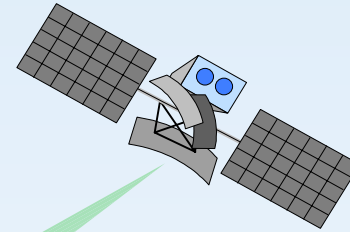
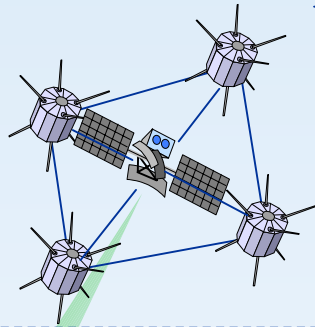


Goals for Bus Design

- ***Goal: Provide end-to-end connectivity between satellites and ground systems using IP-based protocols.***
- Architecture Design Objectives:
 - IP Based
 - Plug-and-Play Design
 - Modular
 - Reconfigurable/Extensible
 - Security
 - Data Integrity
 - Distributed Architecture
 - Networked Environment
- Compare and Validate to an Existing Mission
 - TRMM



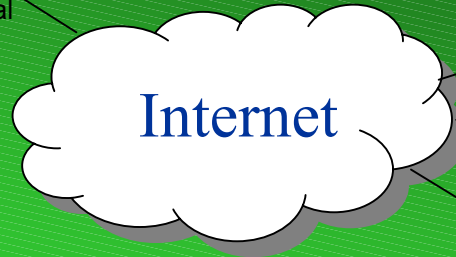
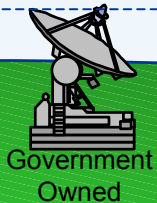
Space Communications and Protocols



Protocols:
IP-based
TCP/IP
CCSDS

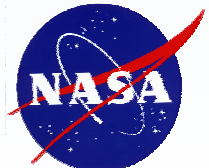
“Protocols”:
IP-based
SCPS
MDP
CCSDS

Protocols:
TCP/IP



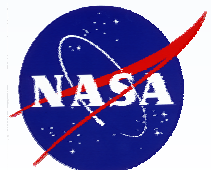
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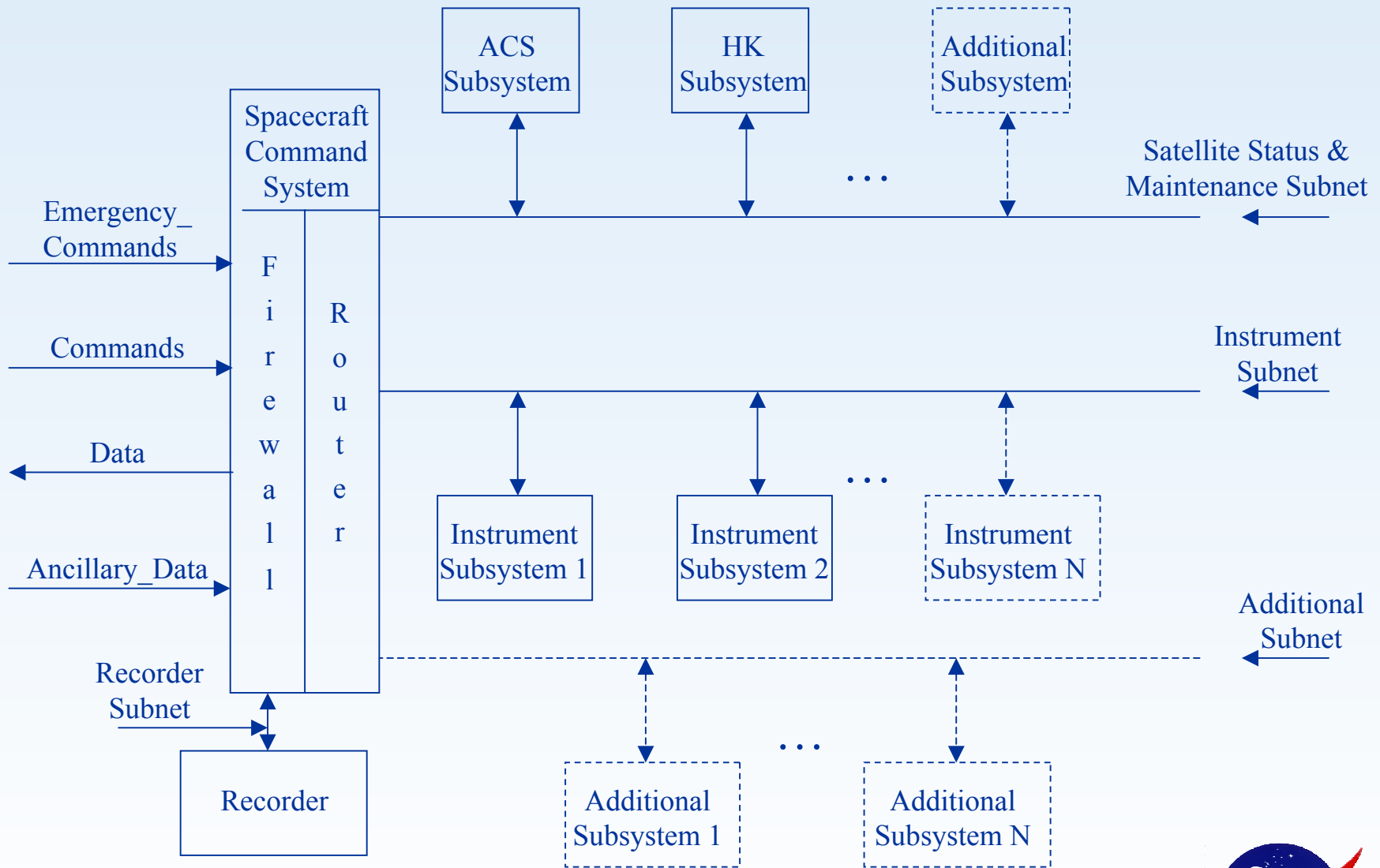


Benefits of an IP-Based Architecture

- Simple Access to Platforms
 - Users will be able to use standard applications
 - Data can be downloaded to either government or commercial installations
- Integration of heterogeneous space platforms
 - Important for constellations
- Focus on new missions
 - The infrastructure will be maintained independently
- Real-time Data Delivery
 - Users can retrieve the data directly from the spacecraft
- Instrument Failover Scenario
 - Eliminates the need for cross-strapping
 - When one instrument fails, another can be brought on-line dynamically

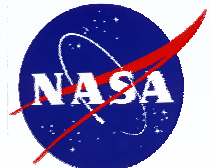


Generic IP-Based Satellite Bus Architecture



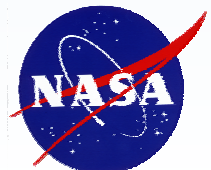
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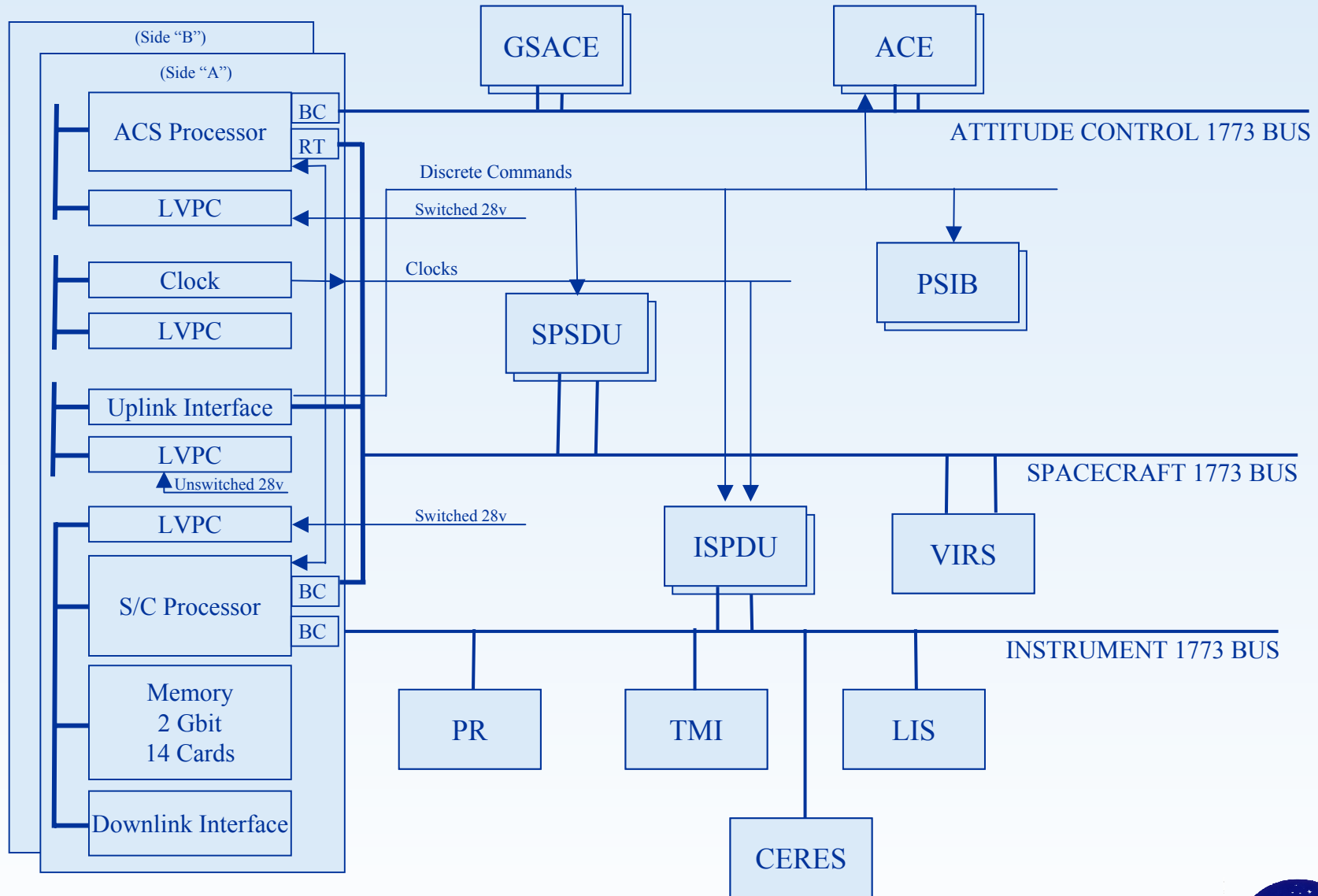


Validating the Design

- Validate the design by comparing against an existing mission.
 - The goal is to determine whether the design can be reconfigured to support the current set of instruments.
- Validate against the Tropical Rainfall Measuring Mission (TRMM)
 - US-Japanese joint mission
 - Launched in 1997
- Reasons for selecting TRMM:
 - Familiarity with Mission and Data Processing
 - Complement of Five (5) Instruments
 - TMI, PR, VIRS
 - CERES, LIS
 - At launch, TRMM was the highest data rate mission for NASA
 - New design has to maintain the data rates.
 - Communications Infrastructure contains typical space components.
 - 1773 Busses
 - Communications using CCSDS

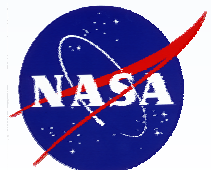


Current TRMM Architecture

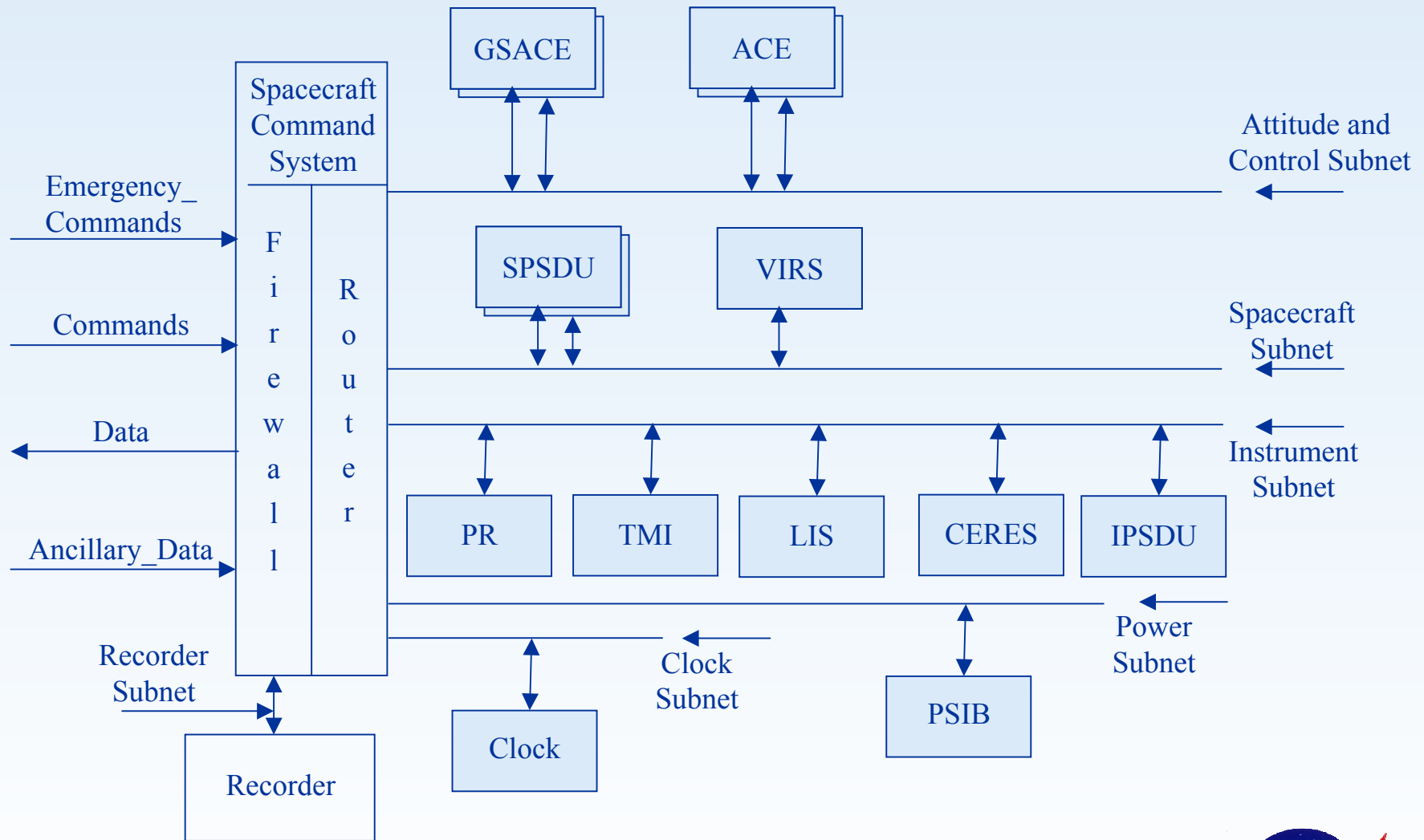


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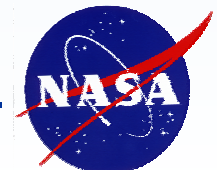


TRMM IP-Based Architecture



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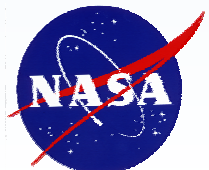
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Note: Spacecraft Command System contains both the Uplink and Downlink Interfaces

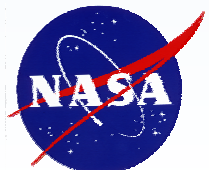
Did the design meet the goals?

- IP-Based
 - Bus contains IP instruments connected to an Ethernet backbone.
 - Protocol will be TCP/IP
- Plug-and-Play Design
 - Instruments will plug directly into the backbone.
 - Instruments will dynamically configure themselves.
- Modular
 - The bus is divided into separate subnets.
 - Reduction of Data Traffic by keeping the type of traffic on its own subnet.
 - Instruments can collect, store, and transmit the data.
- Reconfigurable/Extensible
 - The design can be flexible to meet the requirements of the project.
 - Number of subnets or number of instruments on a subnet.
 - Components of the architecture can also be eliminated.



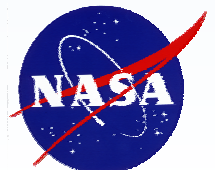
Did the design meet the goals?

- Security
 - Typical Internet Security measures can be applied
 - Firewall Protection – provides a degree of security
 - VPNs provides authentication and encryption of data.
 - Traffic will only be transmitted on the appropriate subnet.
- Data Integrity
 - Data will be TCP/IP packets which provides data integrity checks
 - May consider additional application checksums for sensitive data.
 - Sensitive data can be encrypted.
- Distributed Architecture
 - Eliminated ACS and S/C Processor
 - Primary function is Bus Controller
 - Distributed memory through the Bus
 - IP-Based Components contain memory, processors and buffers.



Did the design meet the goals?

- Network Environment
 - Failover Scenario.
 - If a primary instrument fails, it can be replaced by the secondary instrument
 - Secondary instrument will retrieve IP addresses dynamically
 - Typical Networking Services
 - DHCP
 - Routers
 - Firewalls



Future Work

- Complete a detail design of the bus architecture
 - Look at different designs and implementations
 - Flush out details with the individual components
 - Requires multi-disciplines to complete the task
 - Validate the designs with spacecraft bus designers
- Extend to different and more complex missions
 - Constellations
 - Communication between mother and daughter ships
 - Space Networks
- Emulate the architectures
 - Determine if one configuration is better than another?
 - Validate both normal and anomalous scenarios.
- Componentize the architecture
 - Determine the building blocks
 - Allow projects to “simply” build the communications infrastructure

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Publications:

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